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System Operability Framework

Mid-Assessment Update Webinar, July 2016

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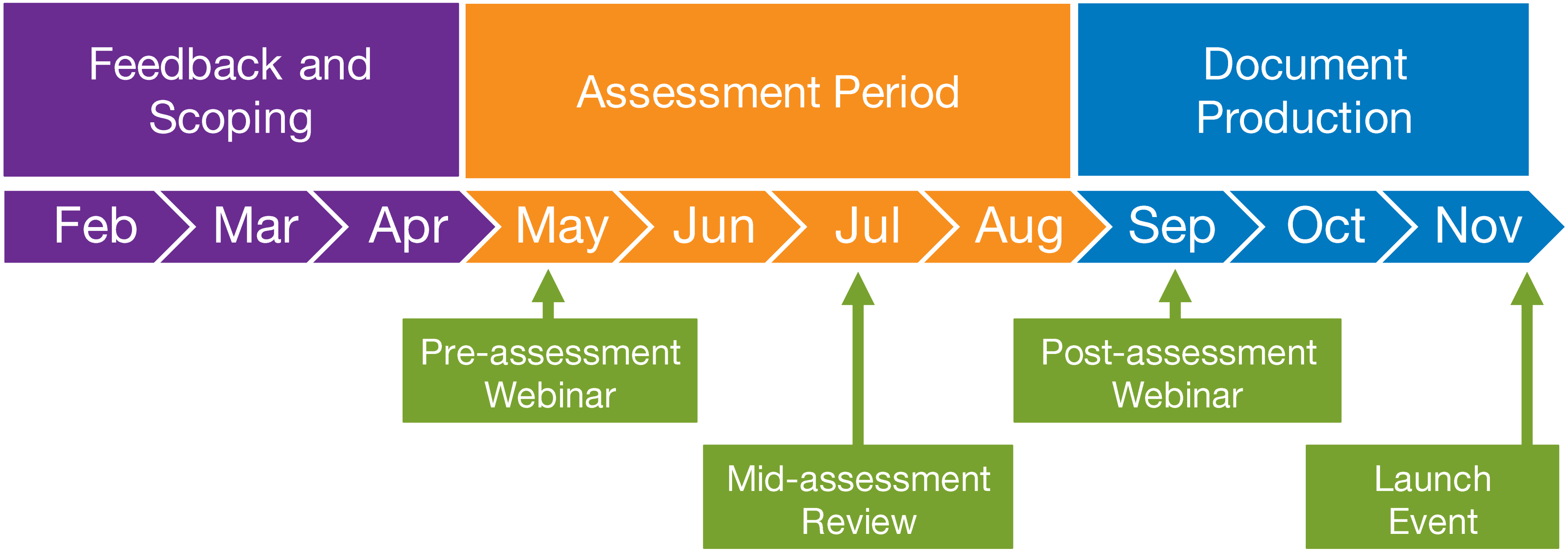
Progress Update



Topics Overview

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Frequency Management

Voltage Management

Whole System Coordination

Normal Operation
Undisturbed system

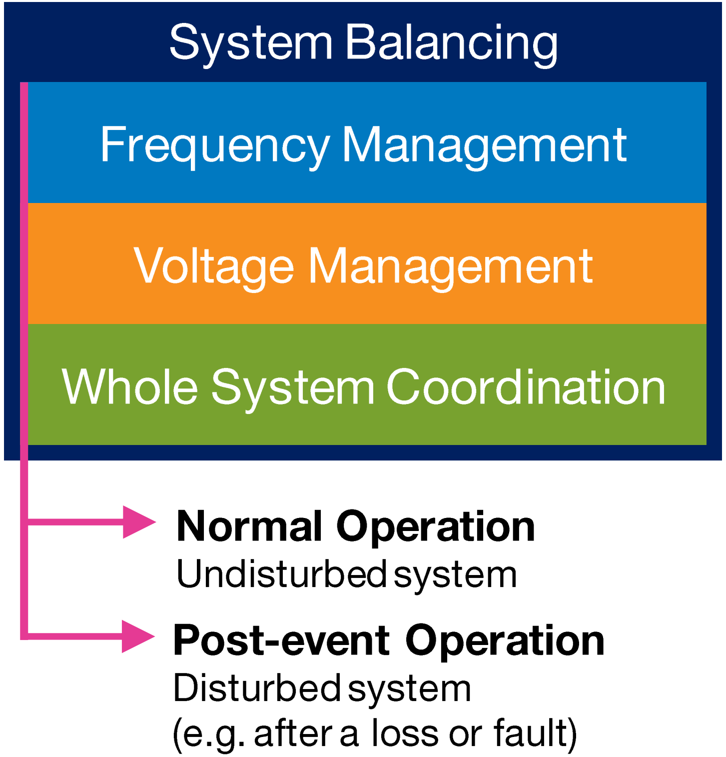
Post-event Operation
Disturbed system
(e.g. after a loss or fault)

- SOF will articulate future requirements according to system operation fundamentals
- The topics will be more accessible with key messages summarised in a “SOF in Six Minutes”
- Normal Operation and Post-event Operation will make drivers behind requirements more explicit
- Detailed assessments are being conducted out to year 10 with snapshot views out to year 20

Detailed Assessments | **Snapshot Assessments**

Year 1 | **Year 10** | **Year 20**

Topics Overview



- SOF will articulate future requirements according to system operation fundamentals
- The topics will be more accessible with key messages summarised in a "SOF in Six Minutes"
- Normal Operation and Post-event Operation will make drivers behind requirements more explicit
- Detailed assessments are being conducted out to year 10 with snapshot views out to year 20
- System Balancing is a new area of analysis which will address within day balancing in the 10 year detailed period and support other topics

System Balancing

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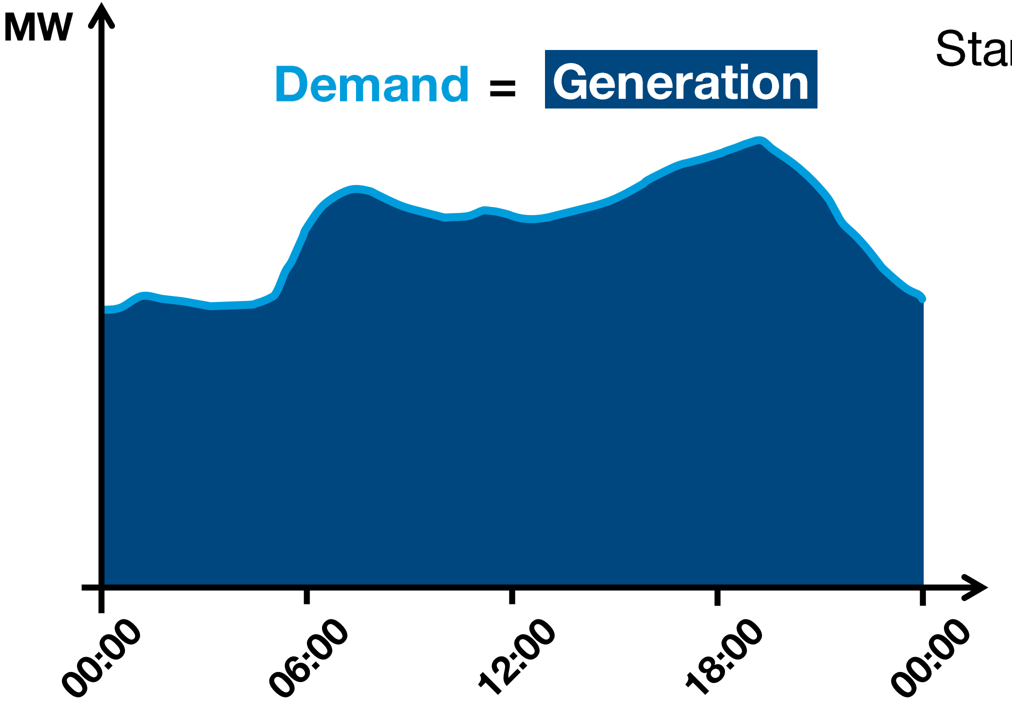
What is it?
Keeping generation matched with the demand throughout the day, at a half-hour resolution.

Why are we doing it?
It informs our view of what sort of generation will be operating in particular conditions.

Together with information about the characteristics of the different types of generation, it improves the insight of our other assessments.

System Balancing – Approach



Start with demand profile...

...and get generation to match

*Plots are illustrative only

Reference Days

Tuesday
9
April
2024

Future day

Potential reference days

31 March 2009 | 7 April 2009 | 14 April 2009 | 21 April 2009

30 March 2010 | 29 March 2011 | 27 March 2012 | ... | 29 March 2016

Tuesday
17
April
2012

Reference day

±14 days

Same day of week

Bank holiday?

Daylight savings?

Reference Days

Tuesday
17
April
2012

Reference day

→

Reference day

Transmission demand profile
Wind and solar conditions

Future Energy Scenarios

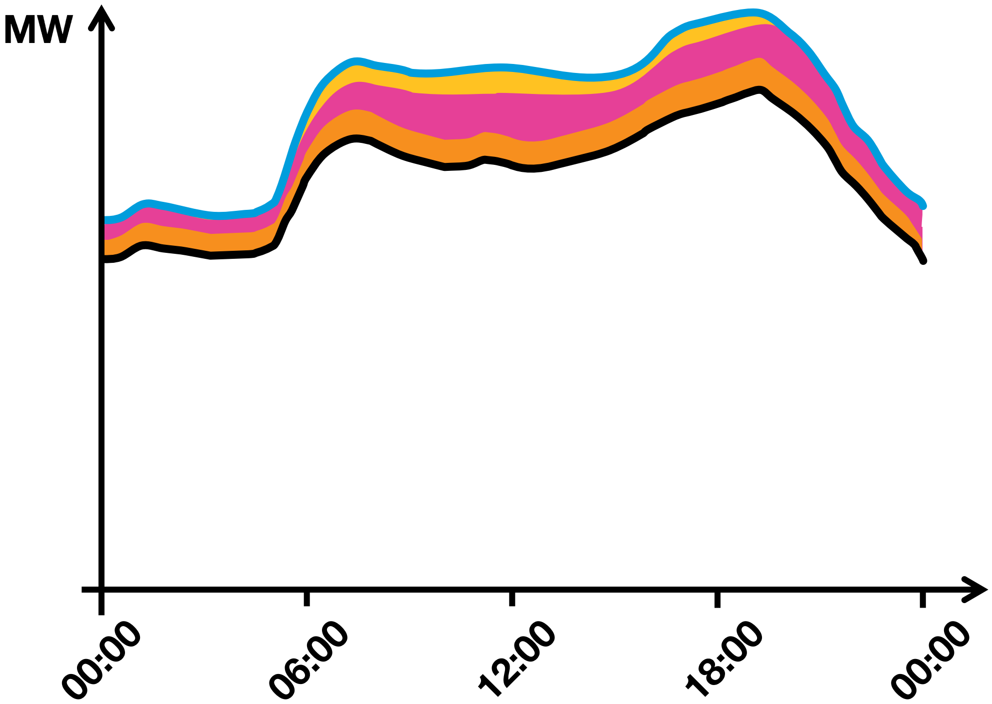
Demand growth
Generation capacities

→

Tuesday
9
April
2024

Future day

Estimating Future Demand



From the reference day...

Real demand

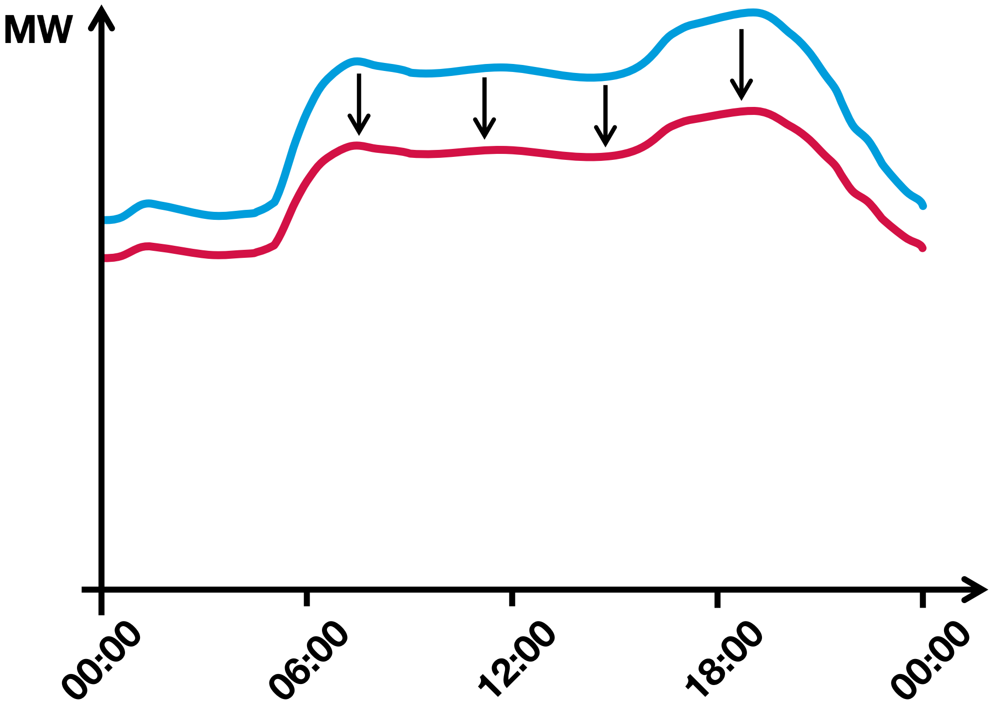
Add embedded generation

Transmission demand

Historic embedded generation output is estimated by applying the historic weather conditions to the historic generation capacities

*Plots are illustrative only

Estimating Future Demand



Real demand (Reference)

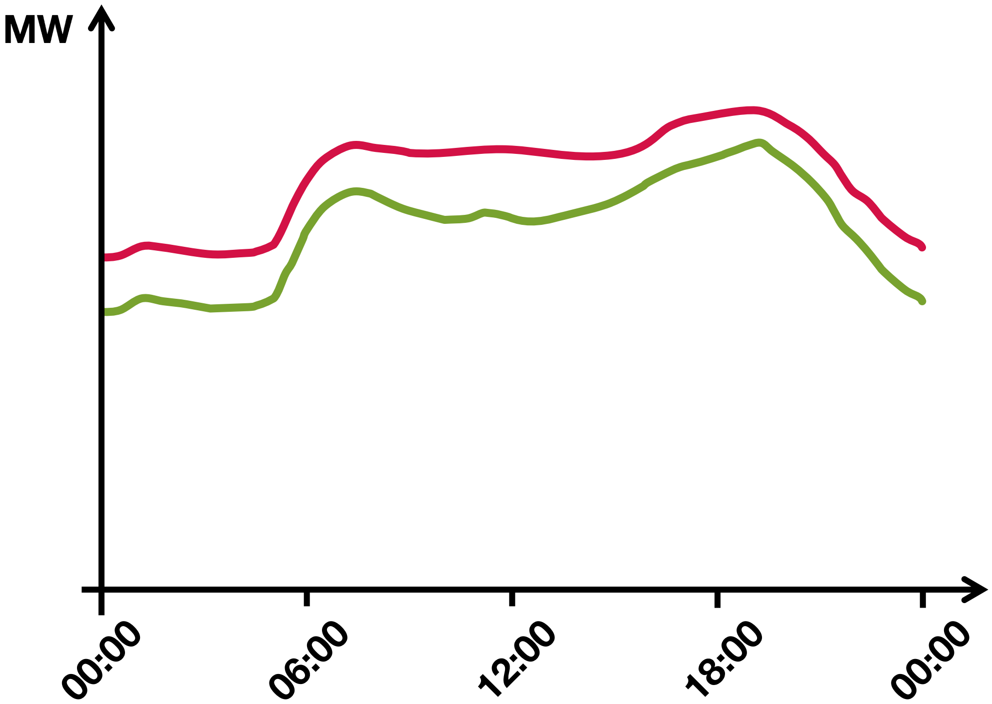
Scale

Real demand (Future)

Scaling is calculated using the relative growth or decline of demand in the Future Energy Scenarios

*Plots are illustrative only

Estimating Future Demand



Real demand (Future)

Subtract embedded generation

Transmission demand (Future)

Future embedded generation output is estimated by applying the reference (historic) weather conditions to the future generation capacities

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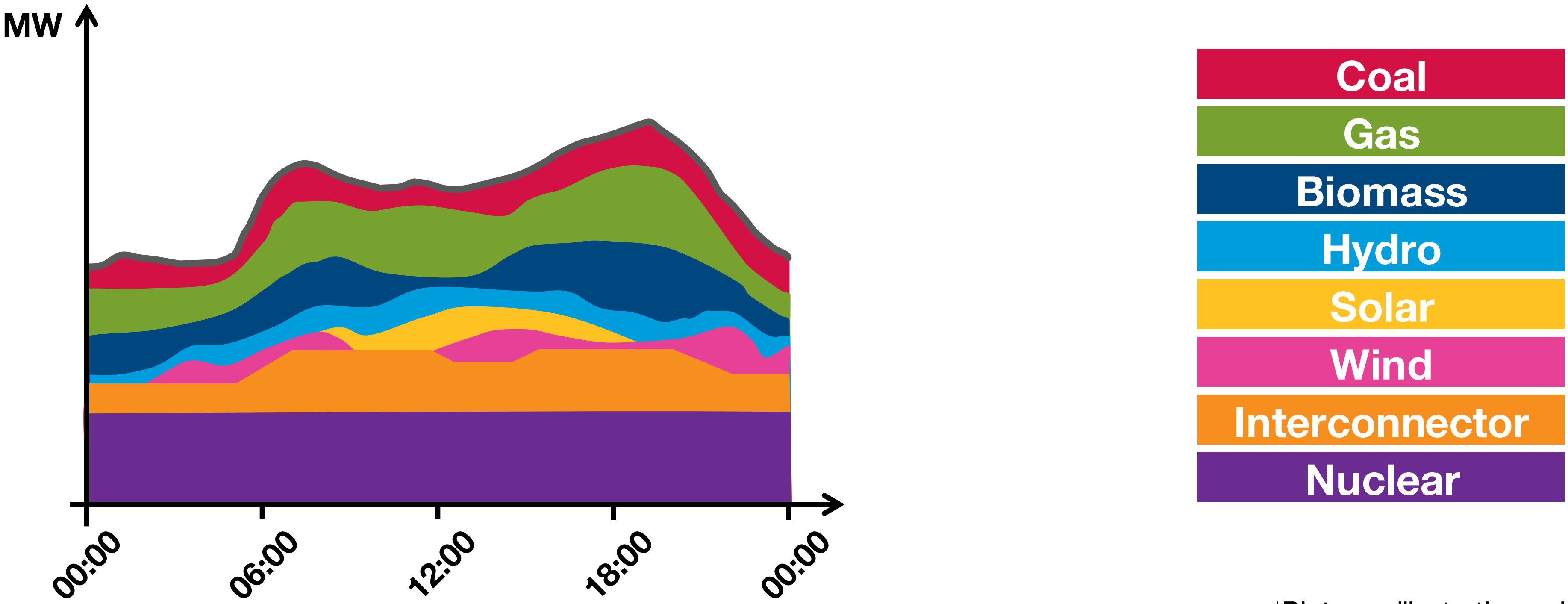
Modelling Generation



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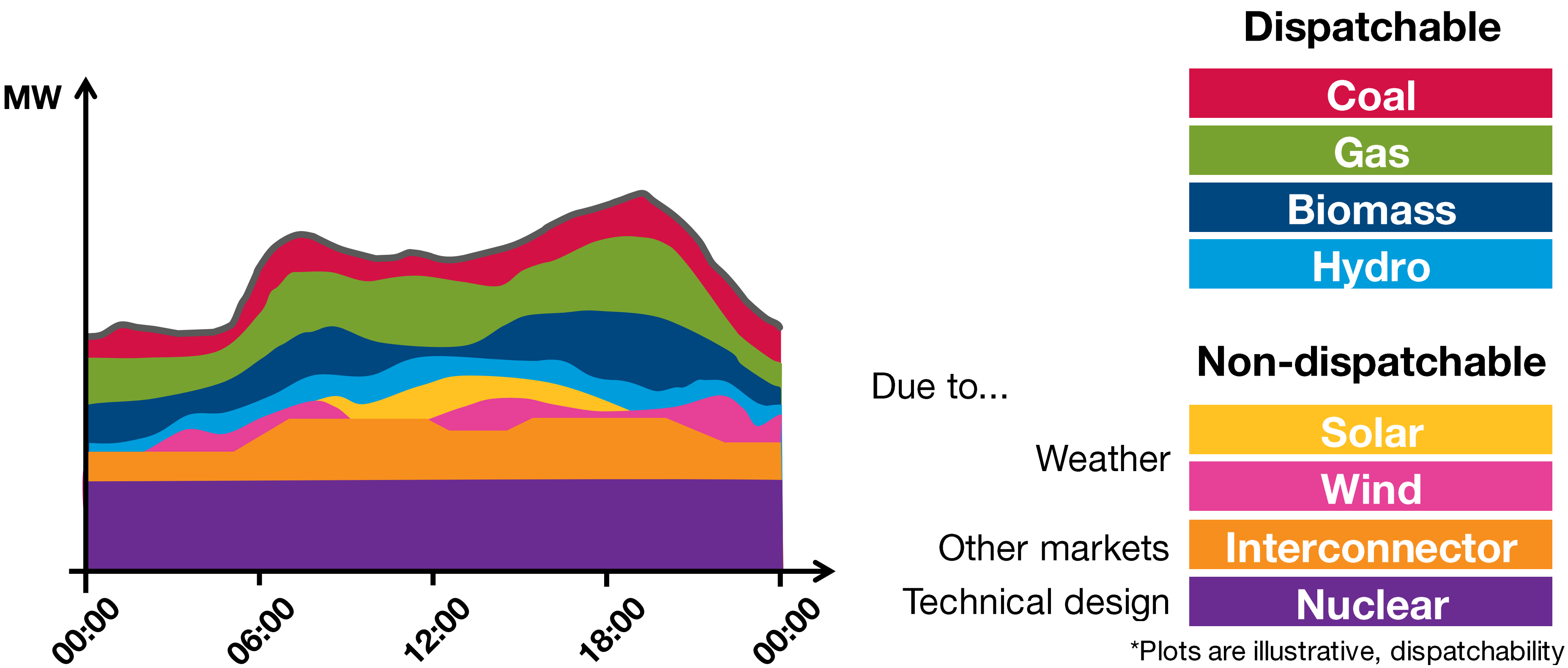
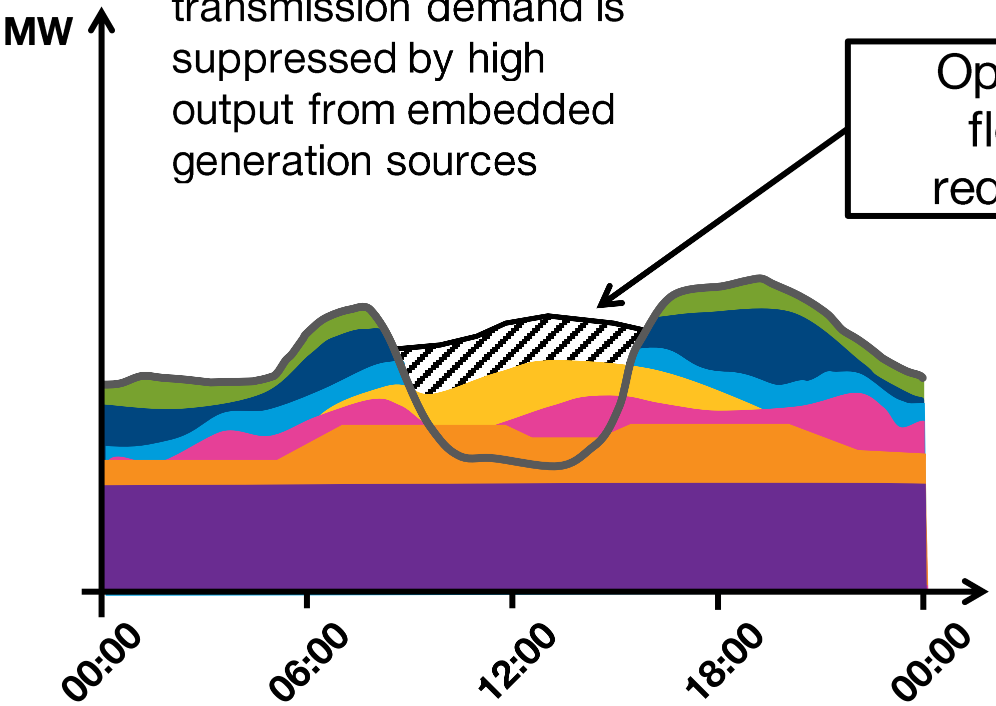
Modelling Assumptions



*Plots are illustrative, dispatchability refers to modelling assumptions only

Modelling Assumptions

On a day when transmission demand is suppressed by high output from embedded generation sources



Dispatchable

- Coal
- Gas
- Biomass
- Hydro

Non-dispatchable

- Solar
- Wind
- Interconnector
- Nuclear

*Plots are illustrative, dispatchability refers to modelling assumptions only

Frequency Management

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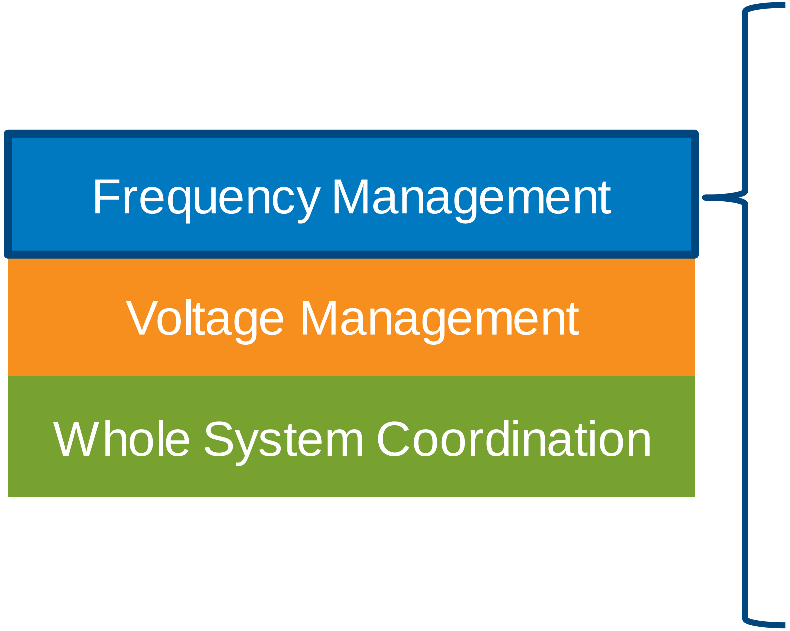


System Inertia

The future system inertia based on system balancing assessment during normal operation

Rate of Change of Frequency

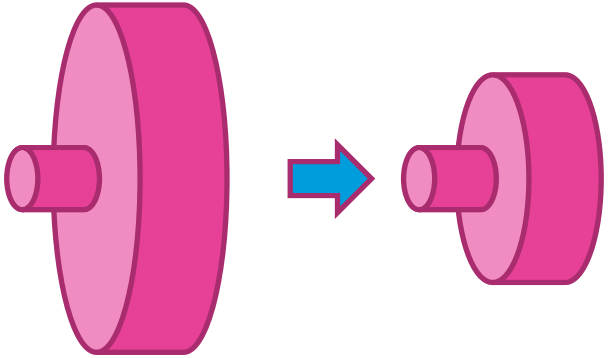
The impact of decreasing system inertia and the largest loss on Rate of Change of Frequency in post-event operation

Containment

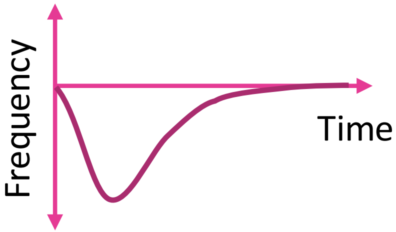
The response requirements such that system frequency is contained in post-event operation

Frequency Management

Inertia can be visualised as a flywheel



High Inertia Low Inertia



*Plots are illustrative only

- System inertia is a measure of the system's resistance to change due to the disinclination of synchronous machines to change speed
- Inertia is desirable because it reduces the Rate of Change of Frequency (RoCoF) following a system disturbance
- When inertia is low, additional response has to be procured for frequency containment to account for an otherwise larger frequency deviation
- Frequency response is effective if it can be provided quickly and in a controlled manner
- As inertia decreases, new and existing frequency management tools will continue to be developed

Frequency Management

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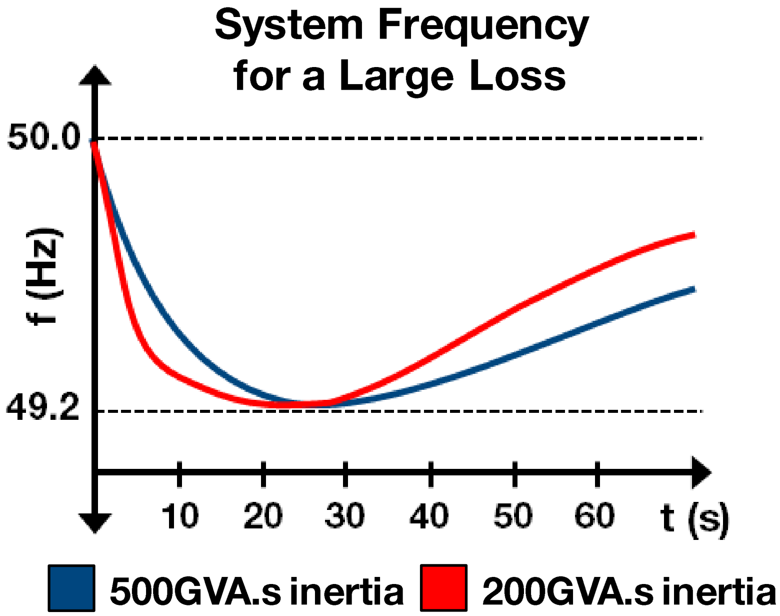

For a 1200MW loss:
~ 500MW primary response @ 500GVA.s
~1000MW primary response @ 200GVA.s

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Voltage Management

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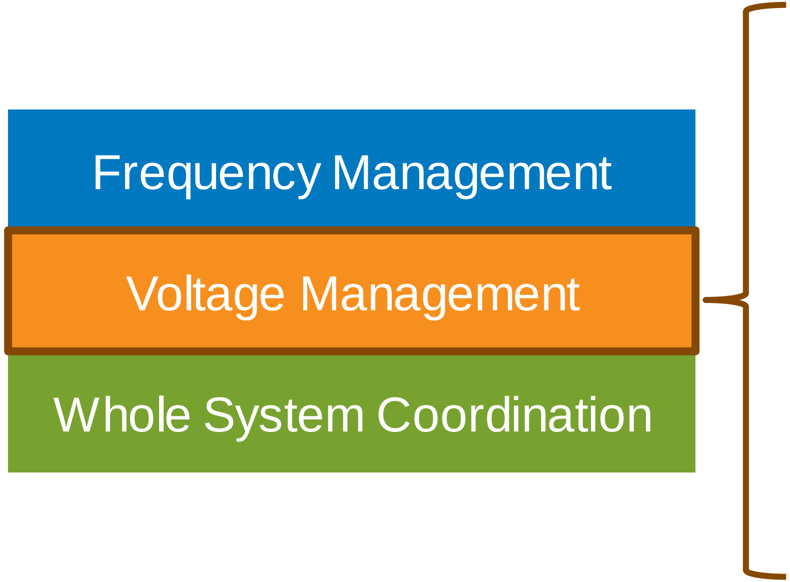


Voltage Profile Following

The requirements for reactive compensation and more flexible control solutions for normal operation

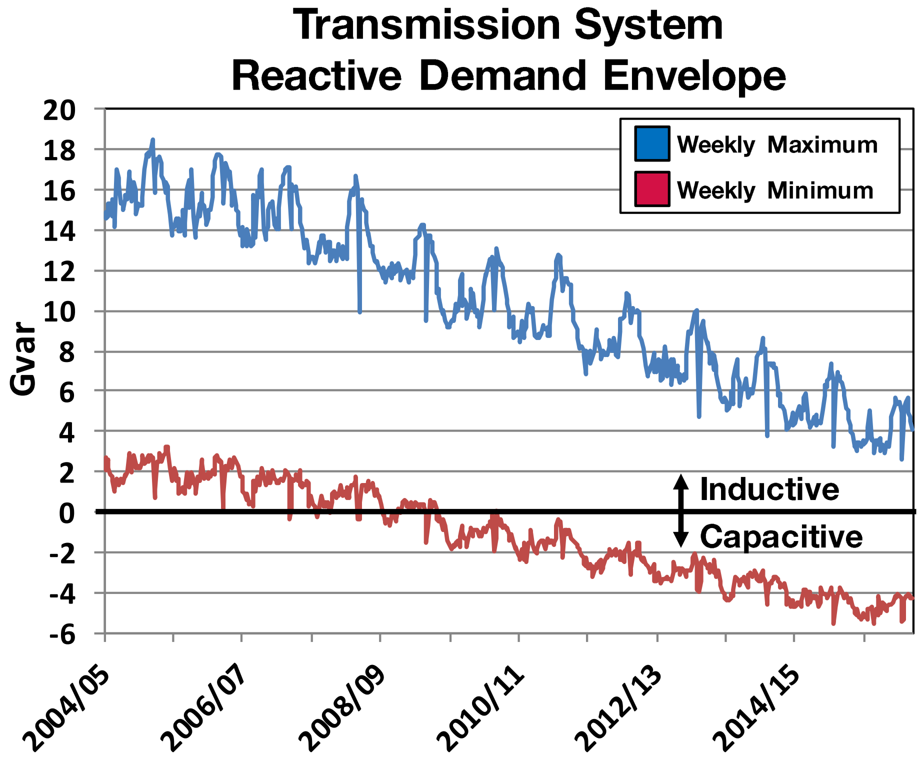
Static/Dynamic Voltage Control

The relationship between static/dynamic voltage control and requirements for post-event operation

Fault Levels and Protection

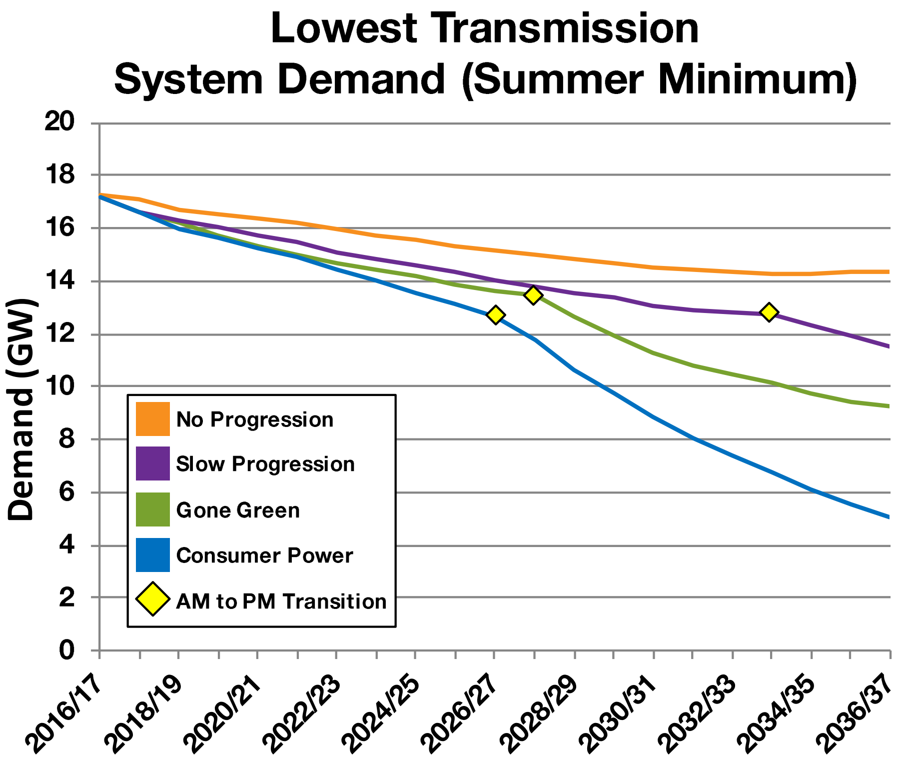
The impact of decreasing fault levels on system strength and protection for post-event operation

Voltage Management



- Transmission system reactive load has become more capacitive in recent years
- Lightly loaded networks are also more capacitive which exacerbates this condition during the summer months
- Reactive compensation can be provided by both network solutions and plant services, however network-based solutions alone are unlikely to be economic in all circumstances
- A mix of compensation types is required in order to manage voltage during both normal operation and post-event operation

Voltage Management



*Morning to afternoon transition due to embedded solar PV growth

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Whole System Coordination

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- Frequency Management
- Voltage Management
- **Whole System Coordination**

Visibility and Control
The system operator's ability to monitor and control generation in normal and post-event operation

Distribution System Case Studies
Assessment of active network management and voltage control from distributed energy resources

Contingency Control Actions
Assessment of future requirements for coordinated whole system contingency control capability

Whole System Coordination

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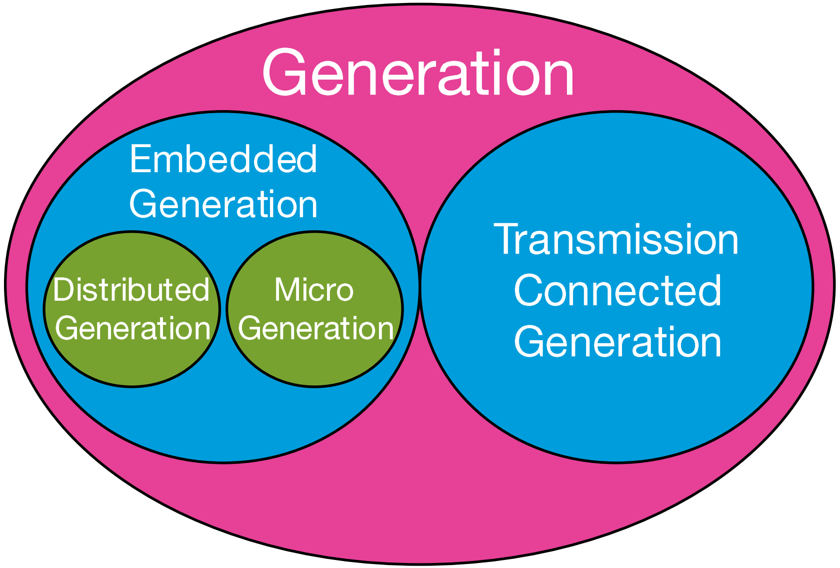
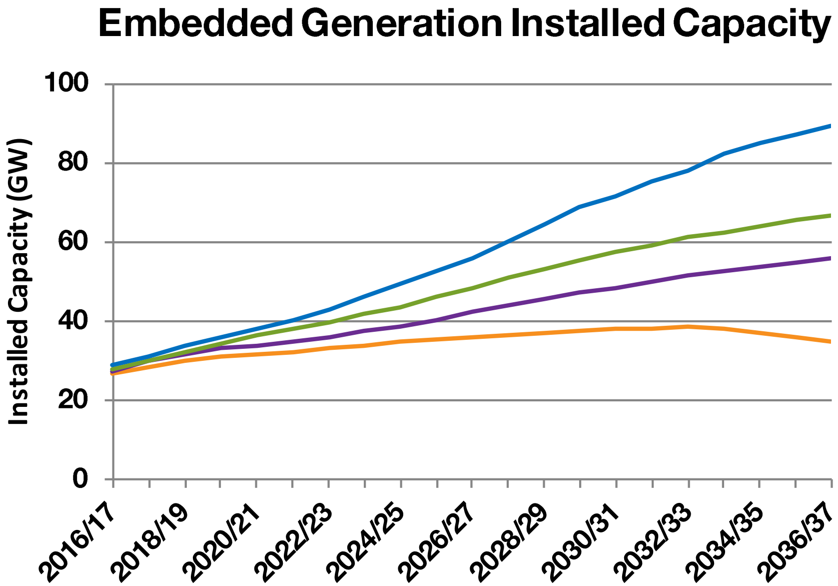


- Whole System Coordination refers to the ability of the system operator to coordinate resources to meet overall system needs
- An increasing proportion of overall generation resource is expected to be embedded under all Future Energy Scenarios
- The ability for embedded resources to provide frequency and voltage support will become increasingly important
- Enhanced visibility and control solutions are required to ensure that embedded generation is able to provide optimal to the whole system

Whole System Coordination



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Whole System Coordination

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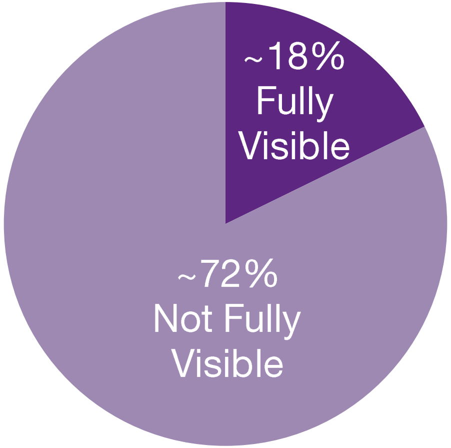
Visibility of Distributed Generation to the System Operator



'Fully Visible' is defined as installed capacity:
>= 50MW (National Grid Transmission)
>= 30MW (Scottish Power Transmission)
>= 10MW (Scottish Hydro Electric Transmission)

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Continuing the Conversation

Thank you for listening.

If you have any further questions about our approach please submit them via chat and we will stay on the line to answer them.

This webinar and future material relating to SOF 2016 will be made available on our website: www.nationalgrid.com/sof

Contact us via email: sof@nationalgrid.com